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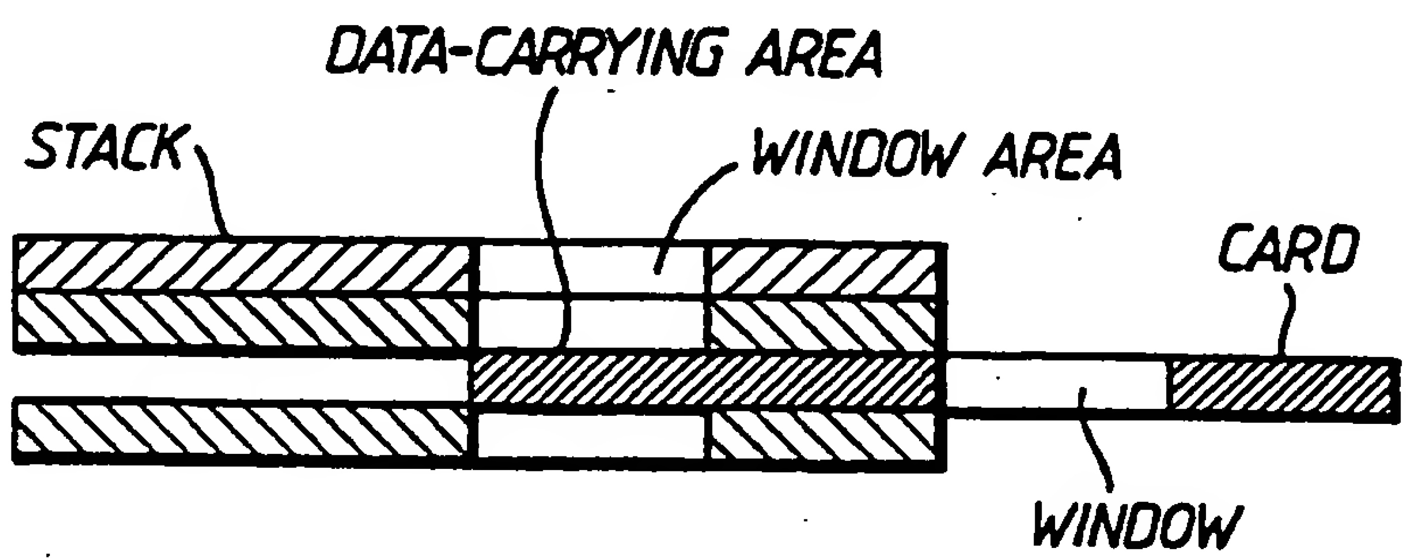
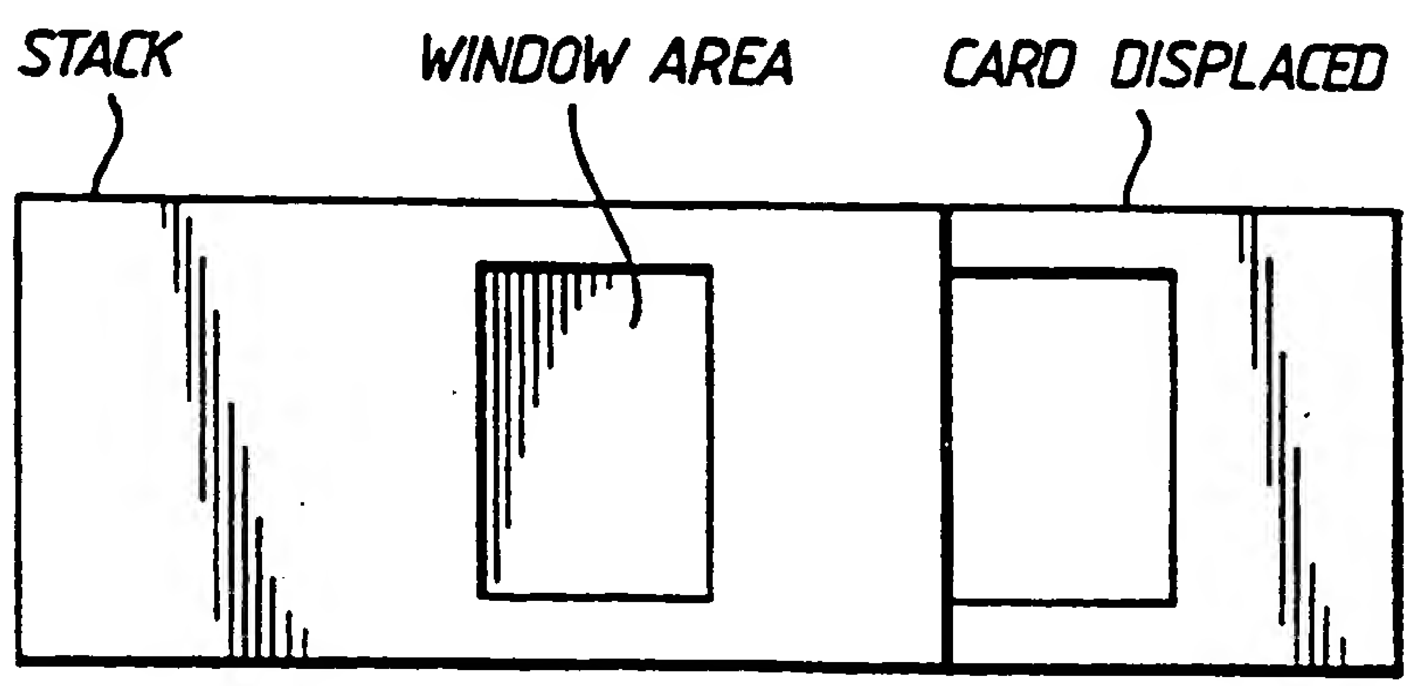
(57) Abstract

In a method for optical data storage with high density, there are employed as the data carrying medium a number of flat, thin memory components in the form of cards or discs. Two or more of the memory components are arranged in a stack, thus enabling each individual memory component to be manoeuvred in relation to the other memory components by means of a manoeuvring device, and a given memory component is moved in relation to the other memory components in the stack in order to write or read data in a data carrying area on the memory component, which can be addressed optically during the write or read operation without interference from the other memory components. A data carrying medium for use with the method for optical data storage with high density comprises a number of flat, thin memory components in the form of cards or discs. A memory component comprises one or more data carrying areas, each data carrying area being capable of including one or more information carrying layers and arranged for optical storage of data. Futhermore, outside the data carrying area(s) the memory component comprises one or more optically transparent areas or windows.





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Method for optical data storage and optical data storage media

The invention concerns a method for optical data storage with high density, wherein there are employed as the data carrying medium a number of flat, thin memory components in the form of cards or discs, and wherein each memory component comprises a plurality of information carrying layers. The invention also concerns a data carrying medium for use with the method for optical data storage with high density, wherein the data carrying medium comprises a number of flat, thin memory components in the form of cards or discs, and wherein each memory component comprises one or more information carrying layers.

In to-day's digital, optical data storage media information is stored in a flat layer on a disc, a card or tape. Circular discs or a rectangular card format are normally used. Even though the data density per area unit in the storage layer is very high, the effective volumetric storage density is not correspondingly high. Each disc or each card has only one or two data storage layers at the most and is typically 0.7-2mm thick in order to provide the necessary rigidity and flatness for read/write operations. Moreover, when such media are placed in a protective cassette, there is a further increase in the volume. Even in the case of so-called "floppy" optical Bernoulli discs which have recently been proposed, the volumetric density is limited by the still substantial volume of the actual floppy disc's substrate, as well as the requirement for a protective housing or sleeve to cover the disc. The limiting effect of the packing on the volumetric density in connection with filing is particularly obvious in libraries which store CD cassettes.

The information carrying layer on present optical data storage media is thin, typically much less than 1 μm. Thus only a small fraction of the volume of the disc or card is used directly for the data storage process. This is also the case even if the protective housing or sleeve is disregarded.

If it were possible to use the entire volume in a typical disc or a card for optical data storage, with a density which corresponded to that which at present can be achieved per area unit, this would be of substantial importance. By extrapolating from an area density which for example corresponds to a bit spacing of 1 μm, the volumetric density could be 10^9 bit/mm^3. In a number of countries considerable efforts have been made to

achieve digital, optical data storage within the volume of a data medium. A number of different methods have been proposed for this purpose:

(a) Holographic methods, in which refraction index changes are coded and read in the bulk material;
(b) three-dimensional positioning of bit points in a volume-filling pattern within a bulk material, selective positioning being achieved by means of sharp focusing of a laser beam, a non-linear response in the medium or an excitation on several wavelengths;
(c) stacking of a number of flat information carrying layers close to one another in a uniform structure which may be a simple bulk material or a number of thin substrates which are attached to one another in order to form a sandwich structure.

Of these above-mentioned methods, (a) and (b) appear to have the potential for the highest volumetric data density, but at the present time they are far from being capable of practical implementation, not least in equipment which should not be too expensive. In connection with the method described under (c), several different techniques are the subject of research and development, cf. the examples mentioned in the following. Even though these techniques appear to have the potential to increase data capacity on each disc or card up to tenfold, they all suffer from the drawback that the carrying substrate has to be manufactured within very strict optical and mechanical tolerances. In addition to the fact that this makes for increased costs, there will also be a good chance that the individual component will be of a substantial thickness.

The following examples of the state of the art and development trends will now be briefly discussed.

(1) A sharply focused laser beam with small depth of field can address a number of information carrying layers at different depths under the surface of a disc or a card by moving the focal point along the laser beam's axis, by analogy with confocal microscopy. At each depth level a thin optical storage layer must be provided in the disc's bulk material, e.g. by forming a dedicated plane structure. The absorbing, reflecting and transmitting properties for each layer must be carefully adapted and controlled in order to avoid crosstalk and covering up the deeper-lying layers. At present it is not clear to what extent these requirements limit

the number of layers which can be used in practice. It appears to be obvious that the very stringent requirements regarding the flatness and optical quality of the disc or card cancel out some of the benefits which are obtained with a monolithic structure.

(2) IBM recently presented a solution which resembles that which is described in the above example, but with a composite disc consisting of a number of thin discs which are joined together to form a sandwich structure, and each of which is equipped with an information carrying layer. Once again the optical properties of each layer must be carefully matched in order to avoid crosstalk and covering up. According to IBM it should be possible to stack up to ten layers in this manner. However, the composite disc is relatively thick and does not appear to be well adapted to the market requirements for inexpensive data carriers in a compact and practical format.

The object of the present invention is therefore to provide a method which can be used in optical data storage with high density and use and especially in a form of volumetric storage. A second object of the invention is to provide a data carrying medium which can be used with the method in order to permit a satisfactorily high, volumetric storage density.

A further object of the invention is that a method and data carrying medium of this kind should meet a requirement for cost-effective data storage systems implemented in a compact and user-friendly format.

The above-mentioned and other objects are achieved with a method according to the invention which is characterized by arranging two or more of the memory components in a stack, thus enabling each individual memory component to be manoeuvred in relation to the other memory components by means of a manoeuvring device, moving a given memory component in relation to the other memory components in the stack by means of the manoeuvring device in order to write or read data in one or more data carrying areas on the memory component, which can be addressed optically during the write or read operation without interference from the other memory components in the stack, together with a data carrying medium which according to the invention is characterized in that a memory component comprises one or more data carrying areas, each data carrying

area being capable of including one or more of the information carrying layers and arranged for optical storage of data, that the memory component outside the data carrying area(s) comprises one or more optically transparent areas or windows, the window having a geometric shape which corresponds to the shape of a data carrying area.

Further advantageous versions of the invention are indicated in the dependent claims. The invention will now be explained in more detail in connection with embodiments and the attached drawing.

Figure 1a,b,c illustrates a first embodiment of the method according to the invention.

Figure 2a,b,c illustrates a second embodiment of the method according to the invention.

Figure 3a,b illustrates a third embodiment of the method according to the invention, in three variants.

Figure 4 illustrates a fourth embodiment of the method according to the invention and a thereby used version of the data carrying medium.

Fig. 1a illustrates a number of card-shaped memory components arranged in a stack and how one memory component is extracted from the stack, thus separating it physically therefrom. The card-shaped memory component, referred to only as the card in the following, which comprises one or more not shown data carrying areas, can now, for example, be identified by means of one or more optically readable identification marks provided on the card, whereupon a not shown write/read device is employed to write or read data in the data carrying area(s) on the card. Subsequently, as shown in fig. 1b, the card is returned to its original position in the stack. The card may be returned to the stack, as illustrated in fig. 1c, the stack now being moved and built up around or over or under the extracted card. When returning the card to the stack, in reality a number of variants are possible, since the card can be inserted into the same position, relative to the other cards in the stack, which it had before being extracted, or the cards in the stack can be reshuffled in relation to one another, thus causing their positions to change. The latter does not represent a problem, since, as mentioned, in most cases each card will be equipped with an identification mark. Alternatively a card for a write/read operation could be extracted only partially from the stack, thus exposing at

least a data carrying area on the card for writing/reading, cf. the card's position in fig. 1b.

It should be understood that each card or each memory component in the stack contains at the most one or only a few information carrying layers, but as opposed to the above-mentioned prior art, the cards in the stack according to the method in the invention are naturally not immovable in relation to one another. It will be seen that during the write/read operation a given card can be addressed optically without any interference whatever from the other cards in the stack.

Fig. 2a shows a similar arrangement, again with memory components in card form arranged in a stack, where one card at a time is removed from the top or the bottom of the stack and transported on a track past a write/read device. The write/read device will rapidly be able to establish the identity of the extracted card by means of the identification mark, and if no write/read operation has to be performed, the card is passed to a second position on the track, where a growing stack of extracted cards is formed. The process continues until the write/read device finds a card which has to undergo a write/read operation. When this has been undertaken and the card transferred to the stack in a second position, the rest of the stack can be quickly transferred on the track, thus forming a single stack in the second position. In a next search cycle in order to find the card which has to be written or read, the stack can be moved back on the track from the second to the first position and the process is repeated, as illustrated in fig. 2b. Alternatively the selected card and the stack which is formed in the second position could be returned to the original stack in the first position after each write/read cycle has been completed. A design of this kind will maintain the original sequence of the cards in the stack, as illustrated in fig. 2c. In this case the track for transport of the cards or the memory components can be understood to be a closed track, since, after completion of a write/read operation or search cycle the cards return to the starting point. As illustrated here and as will normally be the case, the track will be of a linear design, the cards thus being moved in a forward and backward movement, but other designs of closed tracks are also possible, and, for example, they could form a circular loop, with the individual cards being moved past the write/read device by means of a rotary device and then back to the starting point. In this case too the original order of the cards or memory components in the stack will normally be retained.

If the memory components in the stack in consecutive order are physically connected to one another by means of a device on at least one lateral edge of the memory component, the stack can be separated into the individual memory components or cards, the cards thus forming a continuous, e.g. tape-like or disc-like structure. A tape-like structure of this kind of connected cards can similarly be transported in a track past a write/read device arranged in the track for identification or a write/read operation. After completion of a cycle the tape-like structure of the cards is again arranged into a stack, normally in a different position from the original position of the stack, but when the cards are interconnected they will be in the same order in the new stack. A tape-like structure formed by the cards may be transported past the write/read device on a closed track and back to the original position of the stack, where the stack is formed once again. This should naturally be understood to mean that the tape-like structure is an endless loop. If the cards form a disc-like structure, write/read devices and manoeuvring devices must be used which take account of this. When a plurality of write/read devices are used it will be possible to perform simultaneous writing/reading of several cards.

Within the scope of the invention it will also be possible to separate a stack in which the memory components or the cards have a form of interconnection, in other ways dependent on the design of the connecting device. The cards, e.g., may be hinged together at a lateral edge, thus enabling data to be written or read by a movable write/read device. The stack can thereby, e.g., be separated into the individual cards in the same way as the pages are turned in a book or a loose-leaf file system. For a person skilled in the art it will be obvious that both the manoeuvring device and the write/read device must be designed and arranged in a manner which takes into consideration the configuration used for the stack.

In fig. 3a,b a second embodiment of the invention is illustrated in which the stack of memory components or cards is viewed from the side in fig. 3a and from above in fig. 3b. In each card there are provided one or more optically transparent areas or windows which substantially correspond in shape and extent to a data carrying area on the card. When the cards are arranged in a stack, these windows in each card are aligned with one another, thus forming a window area in the stack. By now moving a given card in the stack, a data area on this card can be placed in the window area in the stack and optically

read without interference from the other cards in the stack, through the window area in the stack by means of a write/read device located outside the stack. Thus the card does not need to be extracted from the stack, but is after a write/read cycle pushed into the stack, whereupon the write/read operation with extraction of a second card can be repeated. The windows in each individual card can be made of an optically transparent material, but they can also simply be a through-going opening in the card. Several such windows can naturally be provided in each card, e.g. alternating with data carrying areas and in such a manner that several data carrying areas can be written or read simultaneously through respective corresponding window areas, a number of write/read devices being employed which thus correspond to the number of window areas in the stack.

The use of a data carrying medium with memory components with optically transparent areas or windows can easily be adapted to a method where the movement of the memory component in relation to the other memory components in the stack is not performed by translation, but rather by rotation. In this case the memory component may preferably be designed as an optical disc and the appearance of the stack is as illustrated from the side in fig. 4a and in a top view in fig. 4b. The memory components in a circular, disc-shaped stack are again arranged in such a manner that the windows in the individual discs are in alignment with one another and form a window area in the stack. By rotating a disc in the stack independently of the other discs, a data carrying area on the former can be placed in the stack's window area and written or read therethrough by an optical write/read device and without interference from the other discs in the stack. Here too several windows can be provided in each disc, thus enabling the write/read operation to be undertaken by performing a sector movement of the disc, e.g. over 90° in the case of four windows in the disc. Alternatively a number of windows can also be used here in each disc, thus giving alternating windows and data carrying areas and the reading being carried out when the disc has performed an angular movement which locates the respective data area in alignment with corresponding window areas in the stack. Simultaneous writing/reading can thus be undertaken since separate write/read devices are provided in a number which corresponds to the number of window areas in the stack.

For the sake of simplicity the stacks are illustrated in all the figures with only four memory components. However, a much higher number of memory

components can be stacked, the number depending on the depth of field of the optical write/read device and how complex it is, but also on the parameters for the actual information carrying layer. The mechanical properties of the memory components, such as rigidity, friction and adhesive properties will also be capable of affecting the optimal number of memory components in a stack and similarly the choice of strategies for manoeuvring, moving and extraction of the memory components and the mechanical solutions employed for this purpose. In this connection it should be understood that the manoeuvring device which is not a part of the invention may well be in the form of a per se known mechanical gripping or translation mechanism, but may also make use of electromechanical, pneumomechanical or electropneumatic design solutions. Finally the number of memory components in a stack will also be conditional on the desired random access time and write/read speeds.

For reading data from the data carrying area(s) there can be provided on the surface of the memory component optically active structures, whose configuration is substantially conformal with the data carrying areas and which moreover permit, e.g., the use of wavelength or angle-tunable methods for reading data from the information carrying layer, these being preferably arranged in layers between the optically active structure and an underlying substrate. A data carrying area can thereby consist of several information carrying layers provided at different depths in the memory component. In this connection the optically active structures can be based on the use of refractive elements in the form of microspheres, as these are described in international Patent Application WO 91/11804. In the present method and the present data carrying medium the use of microsphere-based optical structures (lenses) in connection with optical data storage would appear to be well suited, since it permits a high area density for the storage and permits great depth of field, thus enabling thin and flexible substrates to be used, while at the same time it is possible to achieve low friction and little tendency to sticking. It should also be noted that the memory components, i.e. the discs or the cards, should be thin in order to provide the desired high volumetric storage density.

PATENT CLAIMS

1. A method for optical data storage with high density, wherein there are employed as the data carrying medium a number of flat, thin memory components in the form of cards or discs, and wherein each memory component comprises one or more information carrying layers,
characterized by arranging two or more of the memory components in a stack, thus enabling each individual memory component to be manoeuvred in relation to the other memory components by means of a manoeuvring device, moving a given memory component in relation to the other memory components in the stack by means of the manoeuvring device in order to write or read data in one or more data carrying areas on the memory component, which can be addressed optically during the write or read operation without interference from the other memory components in the stack.

2. A method according to claim 1,
characterized by extracting the given memory component from the stack, thus separating it physically therefrom.

3. A method according to claim 1,
characterized by physically connecting the memory components in the stack with one another in order by means of a device on at least one lateral edge of the memory component, the device permitting a separation of the stack into the individual memory components, with the result that after the separation the memory components form a continuous, e.g. tape or disc-like structure.

4. A method according to claim 2 or 3,
characterized in that after a write/read operation the extracted memory component is reinserted into the stack by returning the memory component to the stack.

5. A method according to claim 2 or 3,
characterized in that after a write/read operation on the extracted memory component the stack is manoeuvred in such a manner that the memory component is reinserted into the stack.

6. A method according to claim 3 or 4,
characterized in that the extracted memory component is reinserted into its original position in the stack.

7. A method according to claim 3 or 4, with reference to claim 2,
characterized in that the extracted memory component is reinserted into a randomly selected position in the stack, thus subjecting the memory component in the stack to a reshuffling after the write/read operation.

8. A method according to claim 1,
characterized by extracting a given memory component only partially from the stack in order to free a data carrying area on the memory component, thus enabling it to be addressed optically without interference from the other memory components in the stack, the memory component being reinserted into the stack after the write/read operation.

9. A method according to claim 1,
characterized by extracting the individual memory components successively and in a given order from the stack which is located in a first position on a track device, thus causing the memory components to be transported by means of a manoeuvring device sequentially past an optical write/read device in the track in order to identify the memory component and/or write/read data in data carrying areas on the memory component, and subsequently to again form the stack in a second position on the track, there being no need for the position of the memory components in relation to one another in the stack in its second position to be identical to the position of the memory components in relation to one another in the stack in its first position.

10. A method according to claim 9,
characterized in that a linear track is employed.

11. A method according to claim 10,
characterized in that a closed track is employed, thus enabling the second position to be provided identically to the first position if so desired.

12. A method according to claim 1,
characterized by providing one or more optically transparent areas or windows on each memory component, thus forming a window area in the stack,

each window being arranged and designed in such a manner that the windows are aligned with one another when the memory component is arranged in the stack, and by moving a given memory component in such a manner in relation to the other memory components in the stack that a data carrying area on the given memory component is aligned with the window area in the stack and can be addressed optically therethrough.

13. A method according to claim 12,
characterized by performing the movement of a given memory component by means of a rotary movement independently of the other memory components in the stack, the windows and data carrying areas of the memory components and the stack, together with those provided in the memory components being adapted to the rotary movement.

14. A data carrying medium for use with the method for optical data storage with high density, wherein the data carrying medium comprises a number of flat, thin memory components in the form of cards or discs, and wherein each memory component comprises one or more information carrying layers, characterized in that a memory component comprises one or more data carrying areas, each data carrying area being capable of including one or more of the information carrying layers and arranged for optical storage of data, and that the memory component outside the data carrying area(s) comprises one or more optically transparent areas or windows, the window having a geometric shape which corresponds to the shape of a data carrying area.

15. A data carrying medium according to claim 14,
characterized in that on the surface of the memory component at the data carrying area(s) there is provided an optically active structure which forms a configuration which is substantially conformal with the data carrying area(s).

16. A data carrying medium according to claim 15,
characterized in that each data carrying area comprises one or more of the information carrying layers arranged in layers between the optically active structure and an underlying substrate.

17. A data carrying medium according to claim 14,
characterized in that the memory component is a rectangular card.

18. A data carrying medium according to claim 14, characterized in that the memory component is a circular disc.

19. A data carrying medium according to claim 14, characterized in that the memory component is provided with at least one optically readable, unique identification mark.

20. A data carrying medium for use with the method for optical data storage with high density, wherein the data carrying medium comprises a number of flat, thin memory components in the form of cards or discs, and wherein each memory component comprises one or more information carrying layers, characterized in that one lateral edge of a memory component is provided with a device for connecting the individual memory components physically with one another and in consecutive order in order to form a stack, the device being arranged to permit a separation of the stack into the individual memory components, with the result that after the separation the memory components form a continuous, e.g. tape or disc-like structure.

21. A data carrying medium according to claim 20, characterized in that the memory component is provided with at least one optically readable, unique identification mark.

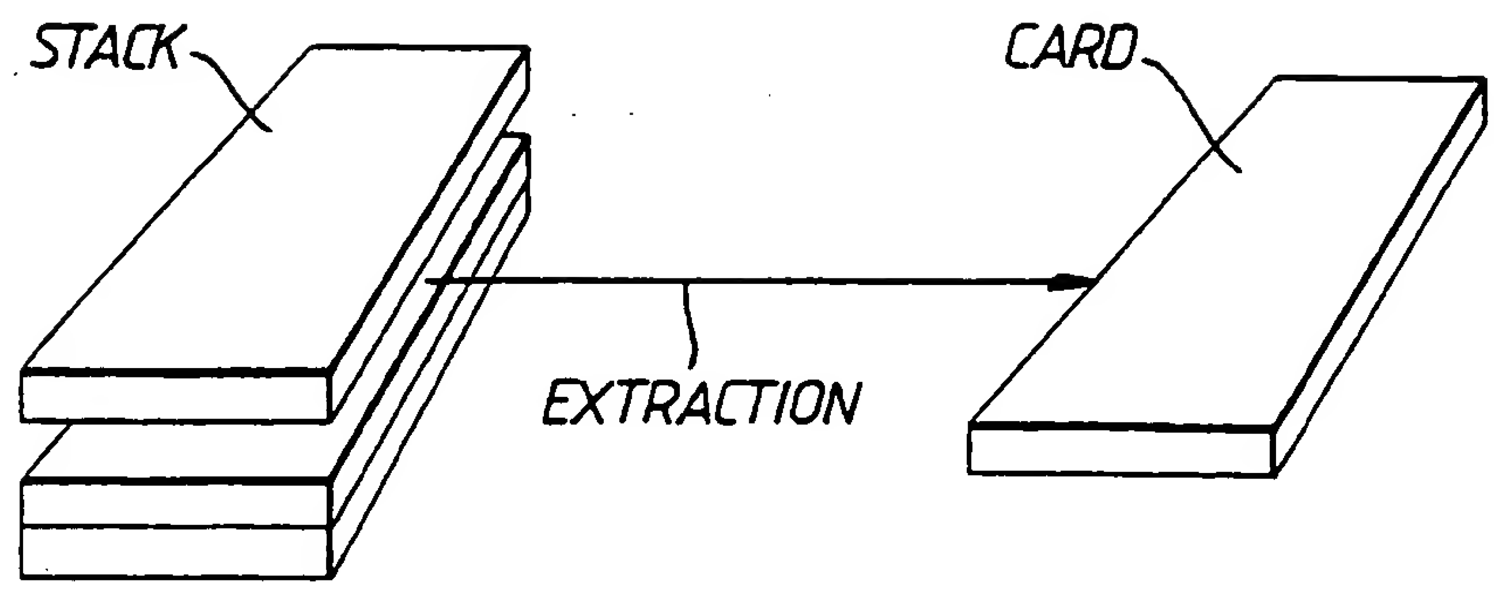

Fig.1a

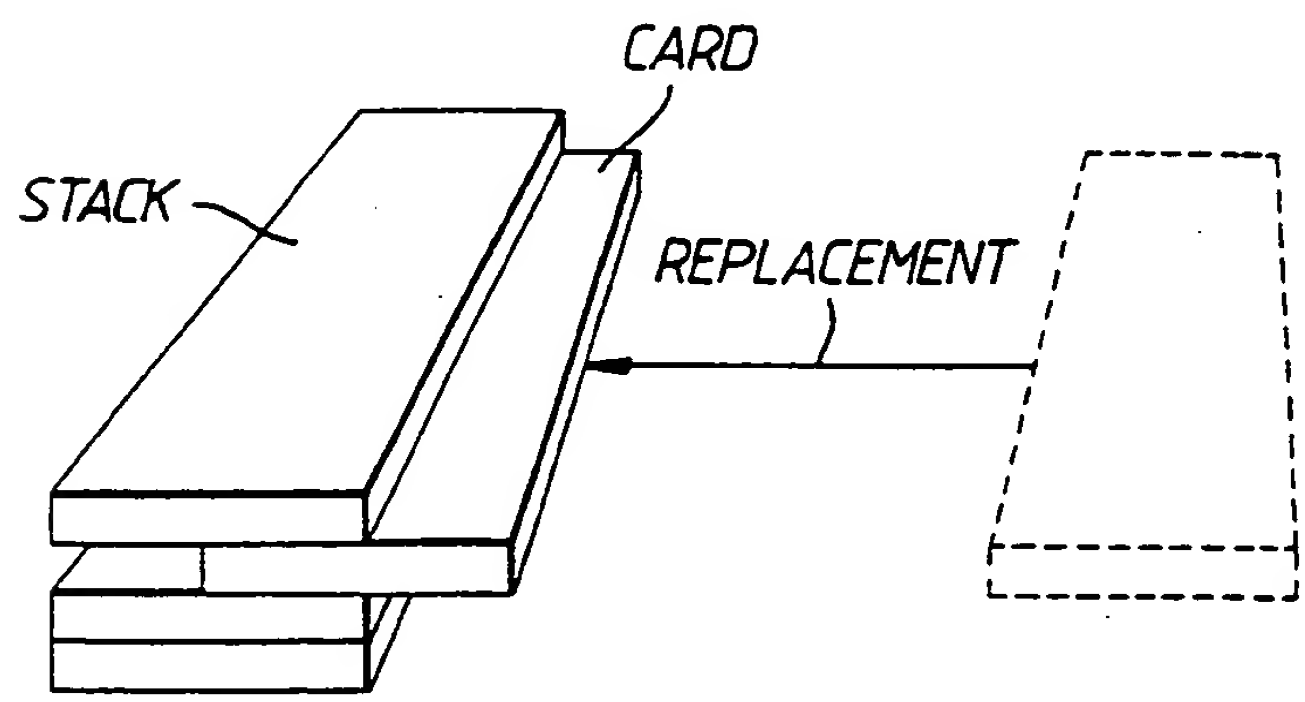

Fig.1b

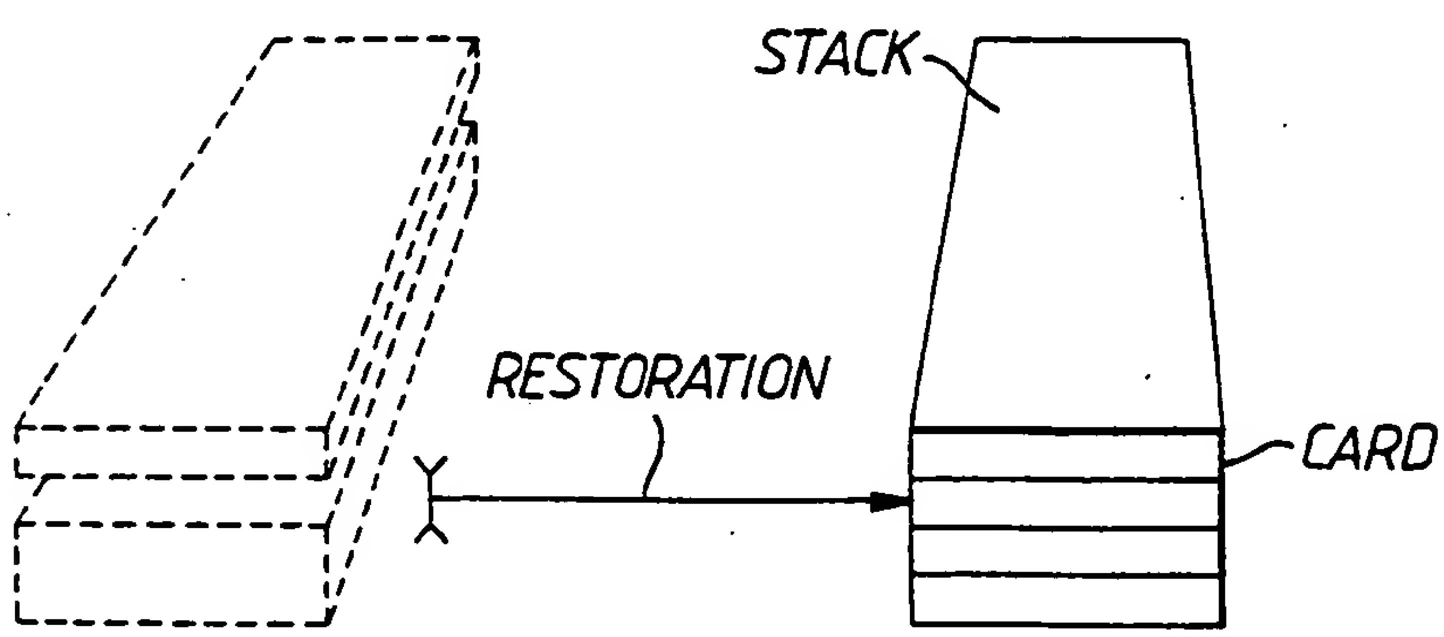

Fig.1c

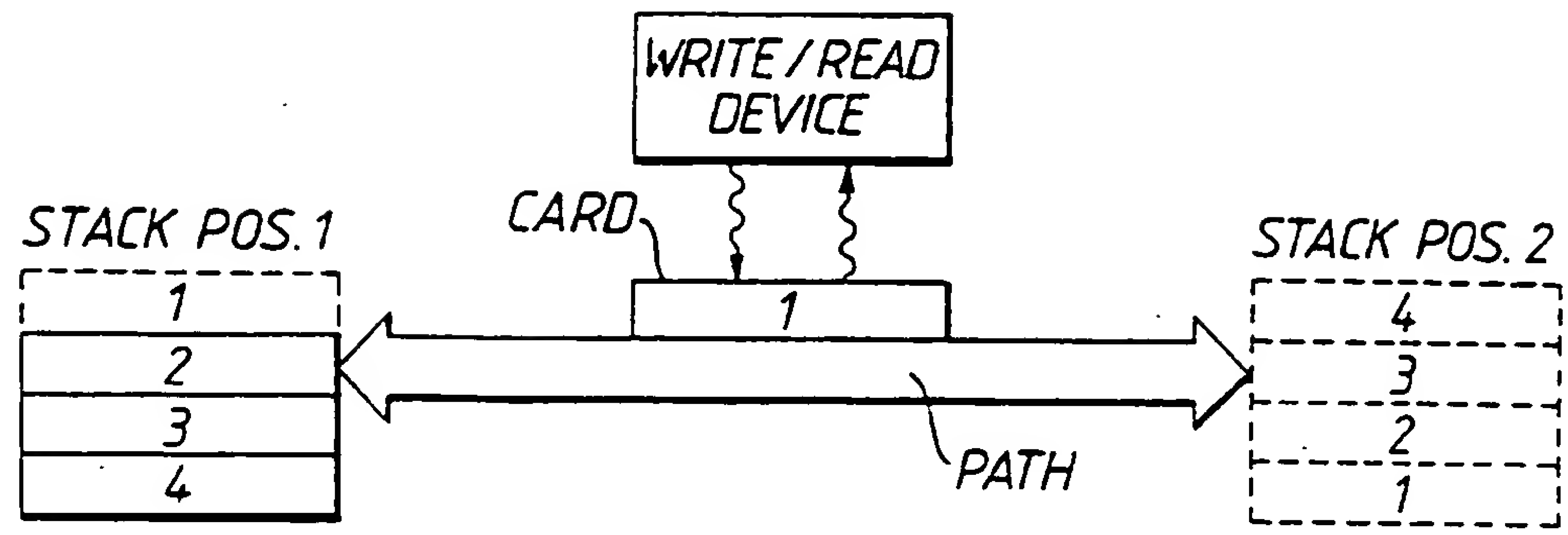

Fig. 2a

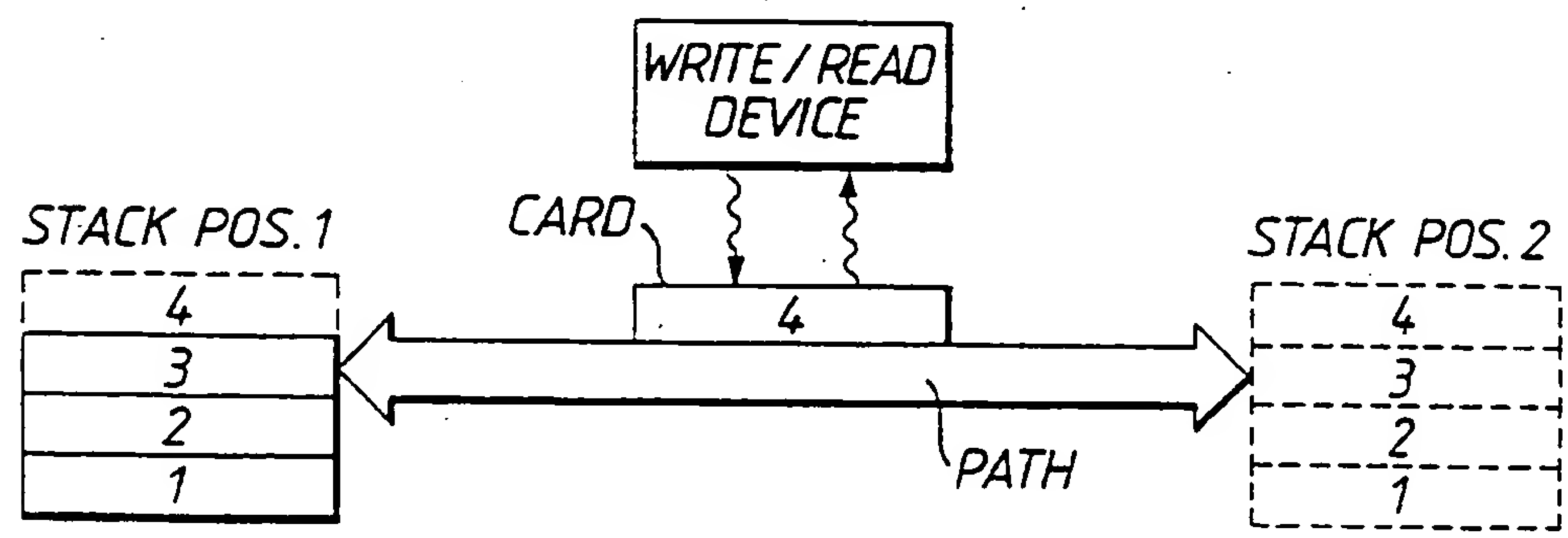

Fig. 2b

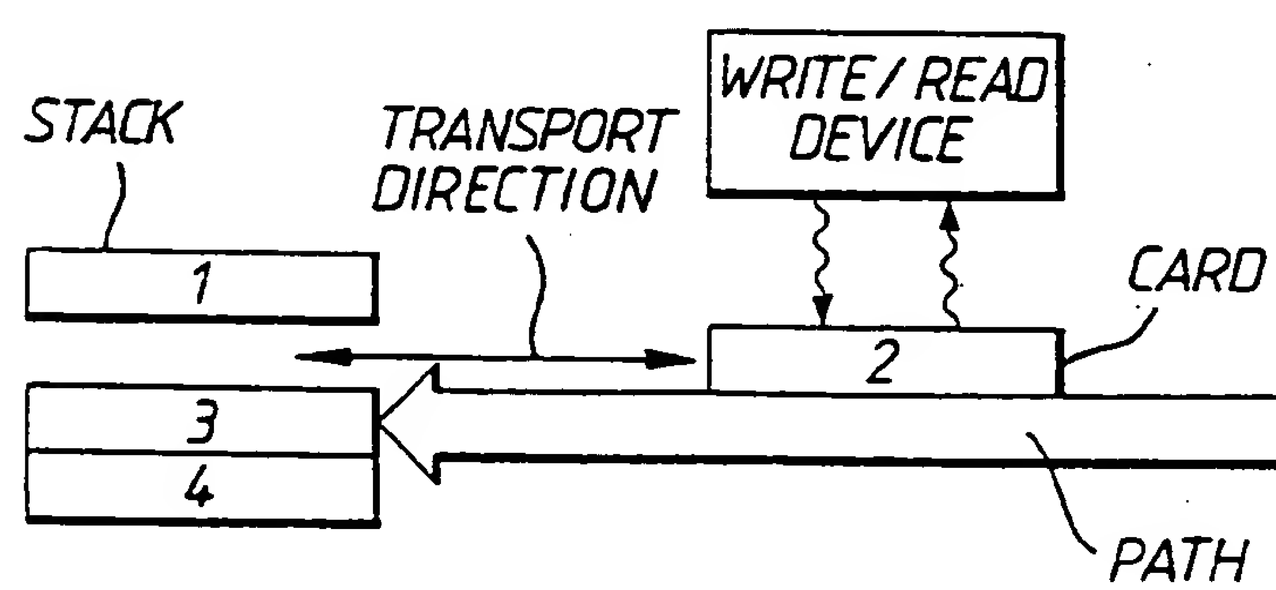

Fig. 2c

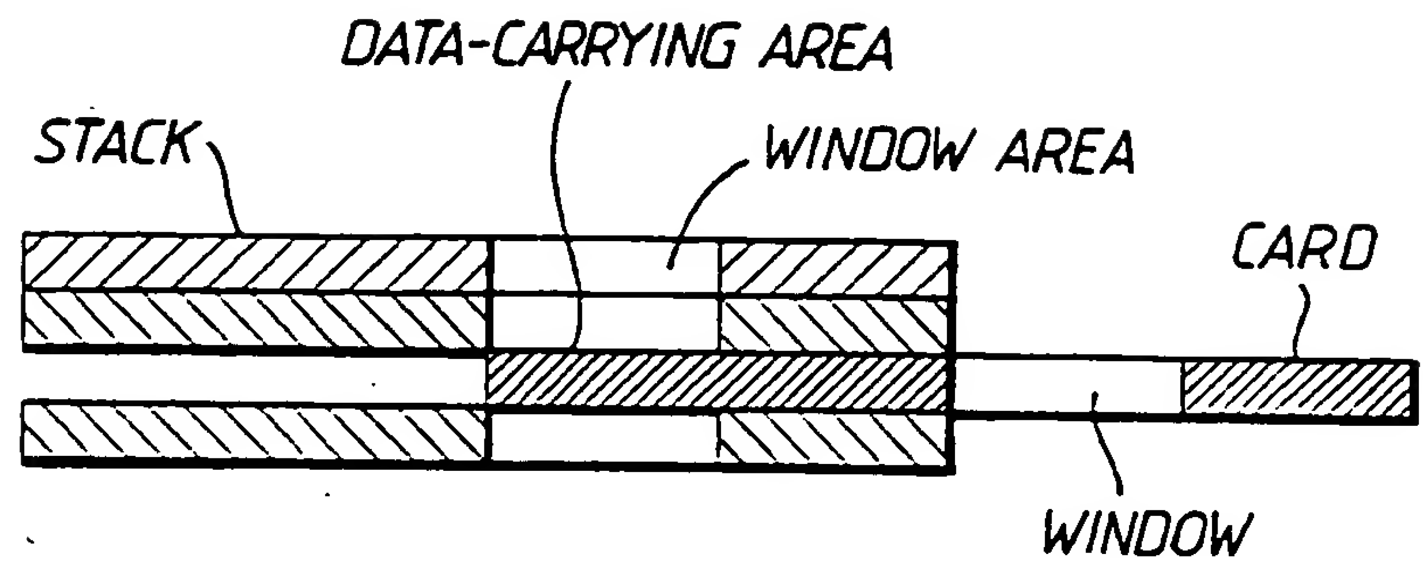
DATA-CARRYING AREA
STACK
WINDOW AREA
CARD
WINDOW

Fig. 3a

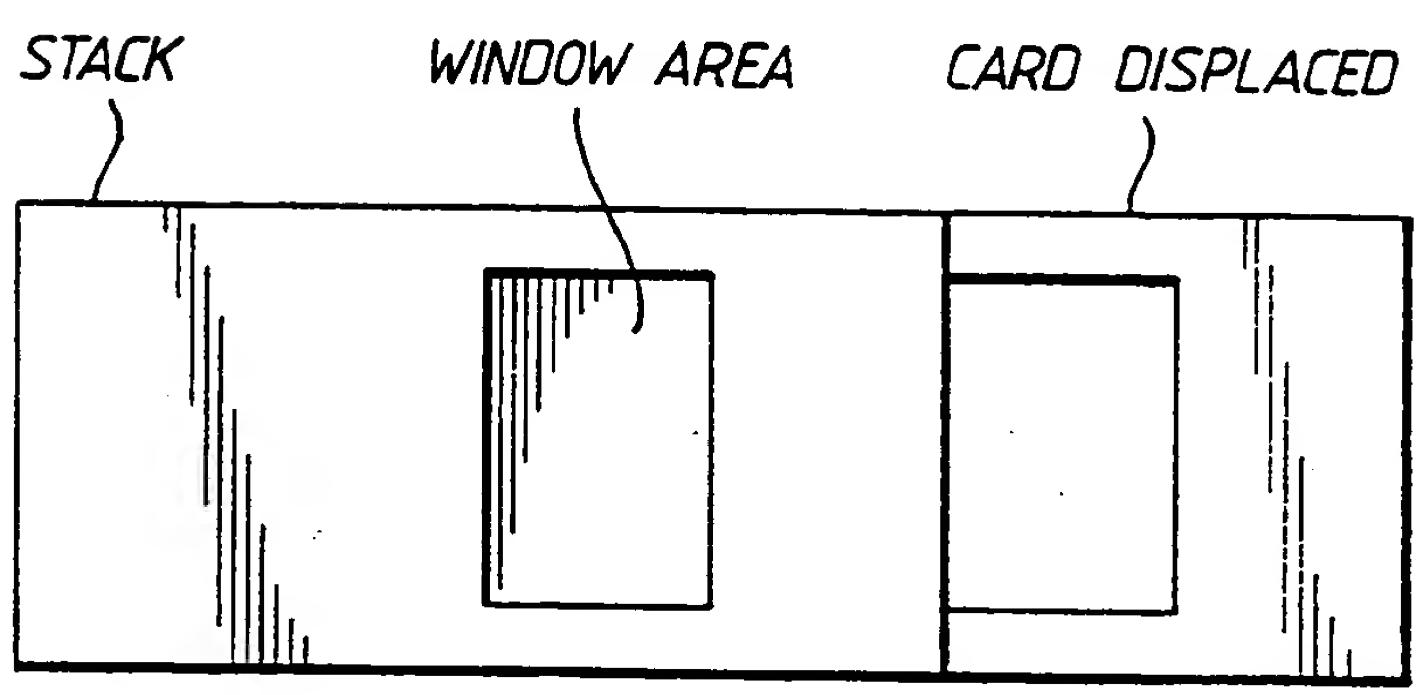
STACK
WINDOW AREA
CARD DISPLACED

Fig. 3b

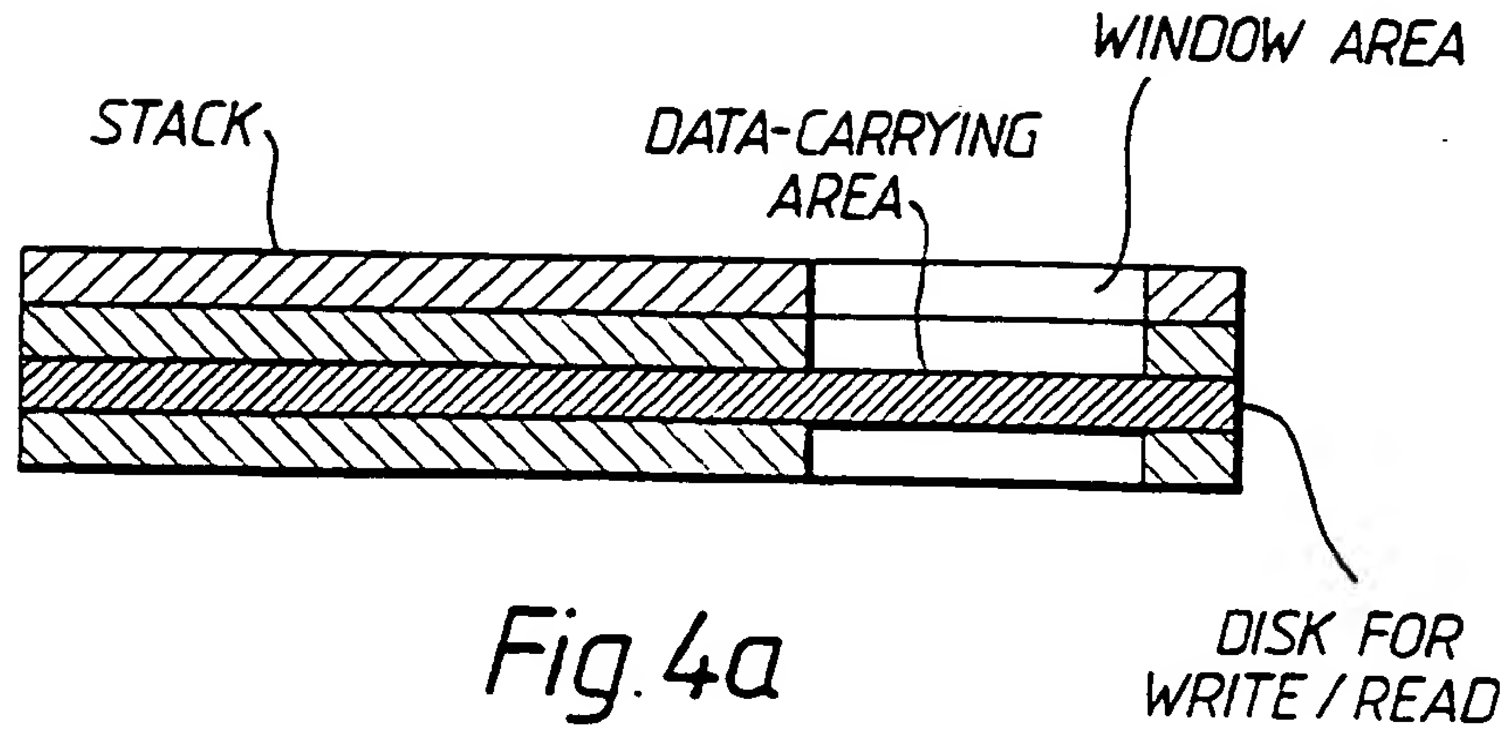
WINDOW AREA
STACK
DATA-CARRYING AREA
DISK FOR WRITE / READ

Fig. 4a

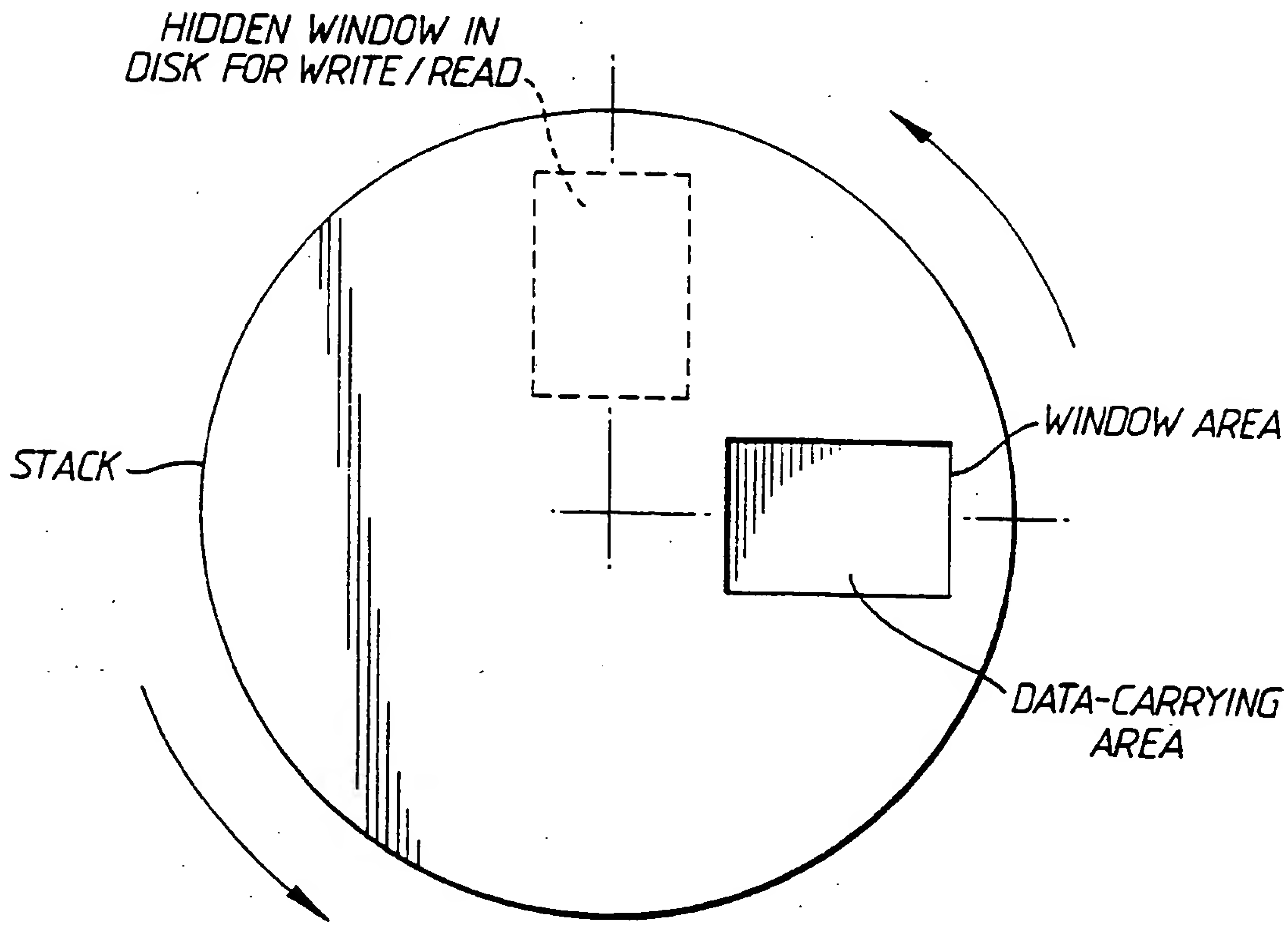
HIDDEN WINDOW IN DISK FOR WRITE / READ
STACK
WINDOW AREA
DATA-CARRYING AREA

Fig. 4b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 96/00156

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G11B 7/00, G11B 17/22, G11C 12/04, G06K 13/07
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G06K, G11B, G11C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CLAIMS, WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 9313529 A1 (INFORMATION OPTICS CORPORATION), 8 July 1993 (08.07.93), page 24, line 18 - page 43, line 7; page 64, line 24 - page 72, line 12; page 78, line 8 - line 22, figure 44	1,2,4-6
A		7,14-17
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X	WO 8803694 A2 (DEUTSCHE THOMSON-BRANDT GMBH), 19 May 1988 (19.05.88), page 2, line 19 - page 3, line 17, figure 1	1,2,4-6,8
A		14,18
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 November 1996	26 -11- 1996
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Bo Gustavsson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 96/00156

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3800942 A (JUNICHI HIRATA ET AL), 2 April 1974 (02.04.74), column 2, line 56 - column 5, line 8	1,2,4-6,8
A		9,14,17,19, 21
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X	Patent Abstracts of Japan, Vol 6,No 5, P-97, abstract of JP,A,56-129989 (SEIEI KOUSAN K.K.), 12 October 1981 (12.10.81)	1,2
A		9,10
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A	US 3731060 A (HILLEL WEINSTEIN), 1 May 1973 (01.05.73), figure 1, see whole document	1,2,4-6,9, 17,19,21
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INTERNATIONAL SEARCH REPORT
Information on patent family members

28/10/96

International application No.
PCT/NO 96/00156

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
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		AU-A-	6072596	26/09/96
		CA-A-	2127101	08/07/93
		EP-A-	0619915	19/10/94
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